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OCCUPATIONAL HEALTH STANDARDS

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PART 528. SPRAY-FINISHING OPERATIONS

Rule 3235 Spray-finishing operations.

(1) Scope. Spray booths or spray rooms are to be used to enclose or confine all spray finishing operations covered by this rule. This rule does not apply to the spraying of the exteriors of buildings, fixed tanks, or similar structures, nor to small portable spraying apparatus not used repeatedly in the same location. [1910.94(c)(8)]

(2) Definitions applicable to this rule.

(a) Aerated solid powders. Aerated powders shall mean any powdered material used as a coating material which shall be fluidized within a container by passing air uniformly from below. It is common practice to fluidize such materials to form a fluidized powder bed and then dip the part to be coated into the bed in a manner similar to that used in liquid dipping. Such beds are also used as sources for powder spray operations. [1910.107(a)(1)]

(b) "Approved" shall mean approved and listed by the following nationally recognized testing laboratories: Underwriters' Laboratories, Inc.; Factory Mutual Engineering Corporation. [1910.107(a)(8)]

(c) Dry spray booth. A spray booth not equipped with a water washing system as described in paragraph (1) of this subsection. A dry spray booth may be equipped with:

(i) Distribution or baffle plates to promote an even flow of air through the booth or cause the deposit of overspray before it enters the exhaust duct [1910.107(a)(5)(i)]; or

(ii) Overspray dry filters to minimize dusts [1910.107(a)(5)(ii)]; or

(iii) Overspray dry filters to minimize dusts or residues entering exhaust ducts [1910.107(a)(5)(iii)]; or

(iv) Overspray dry filter rolls designed to minimize dusts or residues entering exhaust ducts

[1910.107(a)(5)(iv)]; or

(v) Where dry powders are being sprayed, with powder collection systems so arranged in the exhaust to capture oversprayed materials. [1910.107(a)(5)(v)]

(d) Electrostatic fluidized bed. A container holding powder coating material which is aerated from below so as to form an air-supported expanded cloud of such material which is electrically charged with a charge opposite to the charge of the object to be coated; such object is transported through the container immediately above the charged and aerated materials in order to be coated. [1910.107(a)(7)]

(e) Fluidized bed. A container holding powder coating material which is aerated from below so as to form an air-supported expanded cloud of such material through which the preheated object to be coated is immersed and transported. [1910.107(a)(6)]

(f) Listed. See "approved" in paragraph (b) of this subsection [1910.107(a)(9)]

(g) Minimum maintained velocity. Minimum maintained velocity is the velocity of air movement which must be maintained in order to meet minimum specified requirements for health and safety. [1910.94(c)(1)(iv)]

(h) Spraying area. Any area in which dangerous quantities of flammable vapors or mists, or combustible residues, dusts, or deposits are present due to the operations of spraying processes. [1910.107(a)(2)]

(i) Spray booth. A power-ventilated structure provided to enclose or accommodate a spraying operation to confine and limit the escape of spray, vapor, and residue, and to safely conduct or direct them to an exhaust system. [1910.107(a)(3)] [1910.94(c)(1)(ii)] (See sections 103, 104, and 105 of the Standard for Spray Finishing Using Flammable and Combustible Materials, NFPA No. 33-1969.)

(j) Spray-finishing operations. Spray-finishing operations are employment of methods wherein organic or inorganic materials are utilized in dispersed form for deposit on surfaces to be coated, treated, or cleaned. Such methods of deposit may involve either automatic, manual, or electrostatic deposition but do not include metal spraying or metallizing, dipping, flow coating, roller coating, tumbling, centrifuging, or spray washing and degreasing as conducted in self-contained washing and degreasing machines or systems. [1910.94(c)(1)(i)]

(k) Spray room. A spray room is a room in which spray-finishing operations not conducted in a spray booth are performed separately from other areas. [1910.94(c)(1)(iii)]

(l) Waterwash spray booth. A spray booth equipped with a water washing system designed to minimize dusts or residues entering exhaust ducts and to permit the recovery of overspray finishing material. [1910.107(a)(4)]

(3) Location and application. Spray booths or spray rooms are to be used to enclose or confine all operations. Spray-finishing operations shall be located as provided in sections 201 through 206 of the Standard for Spray Finishing Using Flammable and Combustible Materials, NFPA No. 33-1969. [1910.94(c)(2)]

(4) Design and construction of spray booths.

(a) Construction. Spray booths shall be substantially constructed of steel, securely and rigidly supported, or of concrete or masonry except that aluminum or other substantial noncombustible material may be used for intermittent or low volume spraying. Spray booths shall be designed to sweep air currents toward the exhaust outlet. (See Occupational Safety Standard for General Industry and sections 301-304 and 306-310 of the Standard for Spray Finishing Using Flammable and Combustible Materials, NFPA No. 33-1969.) For a more detailed discussion of fundamentals relating to this subject, see ANSI Z9.2-1960. [1910.107(b)(1)] [1910.94(c)(3)(i)]

(b) Interiors. The interior surfaces of spray booths shall be smooth and continuous without edges and otherwise designed to prevent pocketing of residues and facilitate cleaning and washing without injury. [1910.107(b)(2)]

(c) Distribution or baffle plates.

(i) Distribution or baffle plates, if installed to promote an even flow of air through the booth or cause the deposit of overspray before it enters the exhaust duct, shall be of noncombustible material and readily removable or accessible on both sides for cleaning. Such plates shall not be located in exhaust ducts. (See sections 304 and 305 of the Standard for Spray Finishing Using Flammable and Combustible Materials, NFPA No. 33-1969.) [1910.107(b)(4)] [1910.94(c)(3)(iii)]

(ii) Where effective means, independent of the overspray filters, are installed which will result in design air distribution across the booth cross section, it is permissible to operate the booth without the filters in place.

[1910.94(c)(3)(iii)(b)]

(d) In no case shall combustible material be used in the construction of a spray booth and supply or exhaust duct connected to it. [1910.94(c)(3)(i)(b)]

(e) Dry type overspray collectors (exhaust air filters). In conventional dry type spray booths, overspray dry filters or filter rolls, if installed, shall conform to the following: (See section 305 of the Standard for Spray Finishing Using Flammable and Combustible Materials, NFPA No. 33-1969), and shall only be in a location easily accessible for inspection, cleaning, or replacement. [1910.107(b)(5)] [1910.94(c)(3)(iii)(a)]

(i) The spraying operations except electrostatic spraying operations shall be so designed, installed and maintained that the average air velocity over the open face of the booth (or booth cross section during spraying operations) shall be not less than 100 linear feet per minute.

Electrostatic spraying operations may be conducted with an air velocity over the open face of the booth of not less than 60 linear feet per minute, or more, depending on the volume of the finishing material being applied and its flammability and explosion characteristics. Visible gauges or audible alarm or pressure activated devices shall be installed to indicate or insure that the required air velocity is maintained. Dry spray booths equipped with a filter roll which is automatically advanced when the air velocity is reduced to that specified in this subdivision should be arranged to cause shutdown of spraying operations if the filter roll fails to advance automatically. Maintenance procedures should be established to assure replacing filter pads before excessive restriction to airflow occurs. Filter pads should be inspected after each period of use and clogged filter pads discarded and replaced. Filter rolls shall be inspected to insure proper replacement of filter media. [1910.107(b)(5)(i)]

(ii) The location of filters in a spray booth shall be so as to not reduce the effective booth enclosure of the articles being sprayed. [1910.107(b)(5)(iii)]

(f) Frontal area. Each spray booth having a frontal area larger than 9 square feet shall have a metal deflector or curtain not less than 2-1/2 inches deep installed at the upper outer edge of the booth over the opening. [1910.107(b)(6)]

(g) Unobstructed walkways shall not be less than 6-1/2 feet high and shall be maintained clear of obstruction from any work location in the booth exit or open booth front. In booths where the open front is the only exit, such exits shall be not less than 3 feet wide. In booths having multiple exits, such exits shall not be less than 2 feet wide, provided that the maximum distance from the work location to the exit is 25 feet or less. Where booth exits are provided with doors, such doors shall open outward from the booth. [1910.94(c)(3)(ii)]

(h) Conveyors. Where conveyors are arranged to carry work into or out of spray booths, the openings thereof shall be as small as practical. [1910.107(b)(7)]

(i) Illumination. When spraying areas are illuminated through glass panels or other transparent materials, only fixed lighting units shall be used as a source of illumination. Panels shall effectively isolate the spraying area from the area in which the lighting unit is located, and shall be of a noncombustible material of such a nature or so protected that breakage will be unlikely. Panels shall be so arranged that normal accumulations of residue on the exposed surface of the panel will not be raised to a dangerous temperature by radiation or conduction from the source of illumination. [1910.107(b)(10)]

(j) Lights, motors, electrical equipment, and other sources of ignition shall conform to the requirements of the Occupational Safety Standards for General Industry. (See section 310 and Chapter IV of the Standard for Spray Finishing Using Flammable and Combustible Materials, NFPA No. 33-1969). [1910.94(c)(3)(i)(a)]

(k) Wet or water-wash spray booths.

(i) The water-chamber enclosure, within which intimate contact of contaminated air and cleaning water or other cleaning medium is maintained, if made of steel, shall be 18 gage or heavier and adequately protected against corrosion. [1910.94(c)(3)(iv)(a)]

(ii) Chambers may include scrubber spray nozzles, headers, troughs, or other devices. Chambers shall be provided with adequate means for creating and maintaining scrubbing action for removal of particulate matter from the exhaust air stream. [1910.94(c)(3)(iv)(b)]

(l) Collecting tanks shall be of welded steel construction or other suitable non-combustible material. If pits are used as collecting tanks, they shall be concrete, masonry, or other material having similar properties. [1910.94(c)(3)(v)]

(i) Tanks shall be provided with weirs, skimmer plates, or screens to prevent sludge and floating paint from entering the pump suction box. Means for automatically maintaining the proper water level shall also be provided. Fresh water inlets shall not be submerged. They shall terminate at least one pipe diameter above the safety overflow level of the tank. [1910.94(c)(3)(v)(a)]

(ii) Tanks shall be so constructed as to discourage accumulation of hazardous deposits. [1910.94(c)(3)(v)(b)]

(m) Pump manifolds, risers, and headers shall be adequately sized to insure sufficient water flow to provide efficient operation of the water chamber. [1910.94(c)(3)(vi)]

(5) Design and construction of spray rooms.

(a) Spray rooms, including floors, shall be constructed of masonry, concrete, or other noncombustible material. [1910.94(c)(4)(i)]

(b) Spray rooms shall have noncombustible fire doors and shutters. [1910.94(c)(4)(ii)]

(c) Spray rooms shall be adequately ventilated so that the atmosphere in the breathing zone of the operator shall be maintained in accordance with the requirements of

paragraph (8)(b) of this rule. [1910.94(c)(4)(iii)]

(d) Spray rooms used for production spray-finishing operations shall conform to the requirements for spray booths. [1910.94(c)(4)(iv)]

(6) Ventilation for spray finishing using flammable and combustible materials.

(a) Scope. This subsection applies to flammable and combustible finishing materials when applied as a spray by compressed air, "airless" or "hydraulic atomization," steam, electrostatic methods, or by any other means in continuous or intermittent processes. The subsection also covers the application of combustible powders by powder spray guns, electrostatic powder spray guns, fluidized beds, or electrostatic fluidized beds. The subsection does not apply to outdoor spray application of buildings, tanks, or other similar structures, nor to small portable spraying apparatus not used repeatedly in the same location.

(b) Conformance. Ventilating and exhaust systems shall be in accordance with the Standard for Blower and Exhaust Systems for Vapor Removal, NFPA No. 91-1961, where applicable and shall also conform to the provisions of this subsection. [1910.107(d)(1)]

(c) General. All spraying areas shall be provided with mechanical ventilation adequate to remove flammable vapors, mists, or powders to a safe location and to confine and control combustible residues so that life is not endangered. Mechanical ventilation shall be kept in operation at all times while spraying operations are being conducted and for a sufficient time thereafter to allow vapors from drying coated articles and drying finishing material residue to be exhausted. [1910.107(d)(2)]

(d) Independent exhaust. Each spray booth shall have an independent exhaust duct system discharging to the exterior of the building, except that multiple cabinet spray booths in which identical spray finishing material is used with a combined frontal area of not more than 18 square feet may have a common exhaust. If more than one fan serves one booth, all fans shall be so interconnected that one fan cannot operate without all fans being operated. [1910.107(d)(3)]

(e) Fan-rotating element. The fan-rotating element shall be nonferrous or nonsparking or the casing shall consist of or be lined with such material. There shall be ample clearance between the fan-rotating element and the fan casing to avoid a fire by friction, necessary allowance being made for ordinary expansion and loading to prevent contact between moving parts and the duct or fan housing. Fan blades shall be mounted on a shaft sufficiently heavy to maintain perfect alignment even when the blades of the fan are heavily loaded, the shaft preferably to have bearings outside the duct and booth. All bearings shall be of the self-lubricating type, or lubricated from the outside duct. [1910.107(d)(4)]

(f) Electric motors. Electric motors driving exhaust fans shall not be placed inside booths or ducts. See also the Occupational Safety Standards for General Industry. [1910.107(d)(5)]

(g) Belts. Belts shall not enter the duct or booth unless the belt and pulley within the duct or booth are thoroughly enclosed. [1910.107(d)(6)]

(h) Exhaust ducts. Exhaust ducts shall be constructed of steel and shall be substantially supported. Exhaust ducts without dampers are preferred; however, if dampers are installed, they shall be maintained so that they will be in a full open position at all times the ventilating system is in operation. [1910.107(d)(7)]

(i) Exhaust ducts shall be protected against mechanical damage and have a clearance from unprotected combustible construction or other combustible material of not less than 18 inches. [1910.107(d)(7)(i)]

(ii) If combustible construction is provided with the following protection applied to all surfaces within 18 inches, clearances may be reduced to the distances indicated: [1910.107(d)(7)(ii)]

(A) 28-gage sheet metal on 1/4-inch asbestos mill board. 12 inches
[1910.107(d)(7)(ii)(a)]

(B) 28-gage sheet metal on 1/8-inch asbestos mill board spaced out 1 inch on noncombustible spacers. 9 inches
[1910.107(d)(7)(ii)(b)]

(C) 22-gage sheet metal on 1-inch rockwool batts reinforced with wire mesh or the equivalent. 3 inches
[1910.107(d)(7)(ii)(c)]

(D) Where ducts are protected with an approved automatic sprinkler system, properly maintained, the clearance required in subdivision (i) of this paragraph may be reduced to 6 inches. [1910.107(d)(7)(ii)(d)]

(i) Discharge clearance. Unless the spray booth exhaust duct terminal is from a water-wash spray booth, the terminal discharge point shall be not less than 6 feet from any combustible exterior wall or roof nor discharge in the direction of any combustible construction or unprotected opening in any noncombustible exterior wall within 25 feet. [1910.107(d)(8)]

(j) Air exhaust. Air exhaust from spray operations shall not be directed so that it will contaminate makeup air being introduced into the spraying area or other ventilating intakes, nor directed so as to create a nuisance. Air exhausted from spray operations shall not be recirculated. [1910.107(d)(9)]

(k) Access doors. When necessary to facilitate cleaning, exhaust ducts shall be provided with an ample number of access doors. [1910.107(d)(10)]

(l) Room intakes. Air intake openings to rooms containing spray-finishing operations shall be adequate for the efficient operation of exhaust fans and shall be so located as to minimize the creation of dead air pockets. [1910.107(d)(11)]

(m) Drying spaces. Freshly sprayed articles shall be dried only in spaces provided with adequate ventilation to prevent the formation of explosive vapors. In the event adequate and reliable ventilation is not provided such drying spaces shall be considered a spraying area. (See also MIOSHA safety standards.) [1910.107(d)(12)]

(n) Fixed electrostatic apparatus.

(i) Conformance. Where installation and use of electrostatic spraying equipment is used, such installation and use shall conform to all other subsections of this rule, and shall also conform to the requirements of this subsection. [1910.107(h)(1)]

(ii) Ventilation. Where electrostatic atomization is used, the spraying area shall be so ventilated as to insure safe conditions from a fire and health standpoint. [1910.107(h)(11)]

(o) Electrostatic hand spraying equipment.

(i) Application. This paragraph shall apply to any equipment using electrostatically charged elements for the atomization and/or, precipitation of materials for coatings on articles, or for other similar purposes in which the atomizing device is hand held and manipulated during the spraying operations. [1910.107(i)(1)]

(ii) Conformance. Electrostatic hand spraying equipment shall conform with the other provisions of this subsection. [1910.107(i)(2)]

(iii) Interlocks. The electrical equipment shall be so interlocked with the ventilation of the spraying area that the equipment cannot be operated unless the ventilation fans are in operation. [1910.107(i)(8)]

(iv) Ventilation. The spraying operation shall take place within a spray area which is adequately ventilated to remove solvent vapors released from the operation. [1910.107(i)(9)]

(p) Automobile undercoating in garages.

Automobile undercoating spray operations in garages, conducted in areas having adequate natural or mechanical ventilation, are exempt from the requirements pertaining to spray-finishing operations, when using undercoating materials not more hazardous than kerosene (as listed by Underwriters' Laboratories in respect to fire hazard rating 30-40) or undercoating materials using only solvents listed as having a flash point in excess of 100°F. Undercoating spray operations not conforming to these provisions are subject to all requirements of this rule pertaining to spray-finishing operations. [1910.107(k)]

(q) Powder coating.

(i) Ventilation.

(A) In addition to the provisions of this subsection, where applicable, exhaust ventilation shall be sufficient to maintain the atmosphere below the lowest explosive limits for the materials being applied. All nondeposited air-suspended powders shall be safely removed via exhaust ducts to the powder recovery cyclone or receptacle. Each installation shall be designed and operated to meet the foregoing performance specifications. [1910.107(1)(2)(i)]

(B) Powders shall not be released to the outside atmosphere. [1910.107(1)(2)(ii)]

(ii) Electrostatic fluidized beds. The electrical equipment shall be so interlocked with the ventilation system that the equipment cannot be operated unless the ventilation fans are in operation. [1910.107(1)(7)(v)]

(7) Ventilation (General standard).

(a) Ventilation shall be provided in accordance with provisions of paragraphs (6)(a) through (6)(m) of this rule (see Chapter V of the Standard for Spray Finishing Using Flammable or Combustible Materials, NFPA No. 33-1969), and in accordance with the following: [1910.94(c)(5)(i)]

(i) Where a fan plenum is used to equalize or control the distribution of exhaust air movement through the booth, it shall be of sufficient strength or rigidity to withstand the differential air pressure or other superficially imposed loads for which the equipment is designed and also to facilitate cleaning. Construction specifications shall be at least equivalent to those of paragraph (c) of this subsection. [1910.94(c)(5)(i)(a)]

(ii) All fan ratings shall be in accordance with Air Moving and Conditioning Association Standard Test Code for Testing Air Moving Devices, Bulletin 210, April 1962. [1910.94(c)(5)(i)(b)]

(b) Inlet or supply ductwork used to transport make-up air to spray booths or surrounding areas shall be constructed of noncombustible materials. [1910.94(c)(5)(ii)]

(i) If negative pressure exists within inlet ductwork, all seams and joints shall be sealed if there is a possibility of infiltration of harmful quantities of noxious gases, fumes, or mists from areas through which ductwork passes. [1910.94(c)(5)(ii)(a)]

(ii) Inlet ductwork shall be sized in accordance with volume flow requirements and provide design air requirements at the spray booth. [1910.94(c)(5)(ii)(b)]

(iii) Inlet ductwork shall be adequately supported throughout its length to sustain at least its own weight plus any negative pressure which is exerted upon it under normal operating conditions. [1910.94(c)(5)(ii)(c)]

(c) Ducts shall be so constructed as to provide structural strength and stability at least equivalent to sheet steel of not less than the following thickness: [1910.94(c)(5)(iii)]

DIAMETER OR GREATER DIMENSION

	(U.S. gauge)
Up to 8 inches inclusive	No. 24
Over 8 inches to 18 inches inclusive	No. 22
Over 18 inches to 30 inches inclusive	No. 20
Over 30 inches	No. 18

(i) Exhaust ductwork shall be adequately supported

throughout its length to sustain its weight plus any normal accumulation in interior during normal operating conditions and any negative pressure exerted upon it. [1910.94(c)(5)(iii)(a)]

(ii) Exhaust ductwork shall be sized in accordance with good design practice which shall include consideration of fan capacity, length of duct, number of turns and elbows, variation in size, volume, and character of materials being exhausted. See American National Standard Z9.2-1960 for further details and explanation concerning elements of design. [1910.94(c)(5)(iii)(b)]

(iii) Longitudinal joints in sheet steel ductwork shall be either lock-seamed, riveted, or welded. For other than steel construction, equivalent securing of joints shall be provided. [1910.94(c)(5)(iii)(c)]

(iv) Circumferential joints in ductwork shall be substantially fastened together and lapped in the direction of airflow. At least every fourth joint shall be provided with connecting flanges, bolted together, or of equivalent fastening security. [1910.94(c)(5)(iii)(d)]

(v) Inspection or clean-out doors shall be provided for every 9 to 12 feet of running length for ducts up to 12 inches in diameter, but the distance between clean-out doors may be greater for larger pipes. (See 8.3.21 of American National Standard Z9.1-1951.) A clean-out door or doors shall be provided for servicing the fan, and where necessary, a drain shall be provided. [1910.94(c)(5)(iii)(e)]

(vi) Where ductwork passes through a combustible roof or wall, the roof or wall shall be protected at the point of penetration by open space or fire-resistive material between the duct and the roof or wall. When ducts pass through fire walls, they shall be provided with automatic fire dampers on both sides of the wall, except that three-eighth inch steel plates may be used in lieu of automatic fire dampers for ducts not exceeding 18 inches in diameter. [1910.94(c)(5)(iii)(f)]

(vii) Ductwork used for ventilating any process covered in this rule shall not be connected to ducts ventilating any other process or any chimney or flue used for conveying any products of combustion. [1910.94(c)(5)(iii)(g)]

(8) Velocity and airflow requirements.

(a) Except where a spray booth has an adequate air replacement system, the velocity of air into all openings of a spray booth shall be not less than that specified in Table G-10 for the operating conditions specified. An adequate air replacement system is one which introduces replacement air upstream or above the object being sprayed and is so designed that the velocity of air in the booth cross section is not less than that specified in Table G-10 when measured upstream or above the object being sprayed. [1910.94(c)(6)(i)]

(b) In addition to the requirements in paragraph (a) of this subsection the total air volume exhausted through a spray booth shall be such as to dilute solvent vapor to at least 25 percent of the lower explosive limit of the solvent being sprayed. An example of the method of calculating this volume is given below. [1910.94(c)(6)(ii)]

Example: To determine the lower explosive limits of the most common solvents used in spray finishing, see Table G-11. Column 1 gives the number of cubic feet of vapor per gallon of solvent and column 2 gives the lower explosive limit (LEL) in percentage by volume of air. Note that the quantity of solvent will be diminished by the quantity of solids and nonflammables contained in the finish.

To determine the volume of air in cubic feet necessary to dilute the vapor from 1 gallon of solvent to 25 percent of the lower explosive limit, apply the following formula:

$$\text{Dilution volume required per gallon of solvent} = \frac{4 (100 - \text{LEL}) (\text{cubic feet of vapor per gallon})}{\text{LEL}}$$

Using toluene as the solvent.

(1) LEL of toluene from Table G-11, column 2, is 1.4 percent.

(2) Cubic feet of vapor per gallon from Table G-11, column 1, is 30.4 cubic feet per gallon.

$$(3) \text{ Dilution volume required} = \frac{4 (100 - 1.4) 30.4}{1.4} = 8,564 \text{ cubic feet.}$$

(4) To convert to cubic feet per minute of required ventilation, multiply the dilution volume required per gallon of solvent by the number of gallons of solvent evaporated per minute. [1910.94(c)(6)(ii)]

TABLE G-10
MINIMUM MAINTAINED VELOCITIES INTO
SPRAY BOOTHS

Operating conditions for objects completely inside booth	Crossdraft f.p.m.	Airflow velocities, f.p.m.	
		Design	Range
Electrostatic and automatic airless operation contained in booth without operator	Negligible	50 large booth	50-75
		100 small booth	75-125
Air-operated guns, manual or automatic	Up to 50	100 large booth	75-125
		150 small booth	125-175
Air-operated guns, manual or automatic	Up to 100	150 large booth	125-175
		200 small booth	150-250

Notes:

(1) Attention is invited to the fact that the effectiveness of the spray booth is dependent upon the relationship of the depth of the booth to its height and width.

(2) Crossdrafts can be eliminated through proper design and such design should be sought. Crossdrafts in excess of 100 fpm (feet per minute) should not be permitted.

(3) Excessive air pressures result in loss of both efficiency and material waste in addition to creating a backlash that may carry overspray and fumes into adjacent work areas.

(4) Booths should be designed with velocities shown in the column headed "Design." However, booths operating with velocities shown in the column headed "Range" are in compliance with this rule. [1910.94(c)(6)(i)]

TABLE G-11
LOWER EXPLOSIVE LIMIT OF SOME COMMONLY
USED SOLVENTS

Solvent	Cubic feet of vapor per gallon of liquid at 70EF	Lower explosive limit in percent by volume of air at 70EF
Acetone	44.0	2.6
iso-Amyl acetate	21.6	1.0 ¹
Amyl alcohol	29.6	1.2
iso-Amyl alcohol	29.6	1.2
Benzene	36.8	1.4 ¹
n-Butyl acetate	24.8	1.7
Butyl alcohol	35.2	1.4
Butyl cellosolve	24.8	1.1
Cellosolve	33.6	1.8
Cellosolve acetate	23.2	1.7
Cyclohexanone	31.2	1.1 ¹
1,1-Dichloroethylene	42.4	5.6
1,2-Dichloroethylene	42.4	9.7
Ethyl acetate	32.8	2.5
Ethyl alcohol	55.2	4.3
Ethyl lactate	28.0	1.5 ¹
Methyl acetate	40.0	3.1
Methyl alcohol	80.8	7.3
Methyl cellosolve	40.8	2.5
Methyl ethyl ketone	36.0	1.8
Methyl n-propyl ketone	30.4	1.5
Naphtha (VM&P) (76E Naphtha)	22.4	0.9
Naphtha (100E Flash) Safety Solvent--Stoddard Solvent	23.2	1.1

Solvent	Cubic feet of vapor per gallon of liquid at 70°F	Lower explosive limit in percent by volume of air at 70°F
n-Propyl acetate	27.2	2.0
iso-Propyl acetate	28.0	1.8
Propyl acetate	44.8	2.1
iso-Propyl alcohol	44.0	2.0
Toluene	30.4	1.4
Turpentine	20.8	0.8
o-Xylene	26.4	1.0

¹ At 212°F.

(c)

(i) When an operator must position himself in a booth downstream of the object being sprayed, an air-supplied respirator or other type of respirator approved by the Bureau of Mines, U.S. Department of the Interior or specified in ANSI Z88.2-1969 for the material being sprayed should be used by the operator. [1910.94(c)(6)(iii)(a)]

(ii) Where downdraft booths are provided with doors, such doors shall be closed when spray painting. [1910.94(c)(6)(iii)(b)]

(9) Make-up air.

(a) Clean fresh air, free of contamination from adjacent industrial exhaust systems, chimneys, stacks, or vents, shall be supplied to a spray booth or room in quantities equal to the volume of air exhausted through the spray booth. [1910.94(c)(7)(i)]

(b) Where a spray booth or room receives make-up air through self-closing doors, dampers, or louvers, they shall be fully open at all times when the booth or room is in use for spraying. The velocity of air through such doors, dampers, or louvers shall not exceed 200 feet per minute. If the fan characteristics are such that the required airflow through the booth will be provided, higher velocities through the doors, dampers, or louvers may be used. [1910.94(c)(7)(ii)]

(c)

(i) Where the air supply to a spray booth or room is filtered, the fan static pressure shall be calculated on the assumption that the filters are dirty to the extent that they require cleaning or replacement. [1910.94(c)(7)(iii)(a)]

(ii) The rating of filters shall be governed by test data

supplied by the manufacturer of the filter. A pressure gage shall be installed to show the pressure drop across the filters. This gage shall be marked to show the pressure drop at which the filters require cleaning or replacement. Filters shall be replaced or cleaned whenever the pressure drop across them becomes excessive or whenever the airflow through the face of the booth falls below that specified in Table G-10. [1910.94(c)(7)(iii)(b)]

(d)

(i) Means for heating make-up air to any spray booth or room, before or at the time spraying is normally performed, shall be provided in all places where the outdoor temperature may be expected to remain below 55°F. for appreciable periods of time during the operation of the booth except where adequate and safe means of radiant heating for all operating personnel affected is provided. This replacement air during the heating seasons shall be maintained at not less than 65°F. at the point of entry into the spray booth or spray room. When otherwise unheated make-up air would be at a temperature of more than 10°F. below room temperature, its temperature shall be regulated as provided in section 3.6.3 of ANSI Z9.2-1960. [1910.94(c)(7)(iv)(a)]

(ii) As an alternative to an air replacement system complying with the preceding section, general heating of the building in which the spray room or booth is located may be employed provided that all occupied parts of the building are maintained at not less than 65°F. when the exhaust system is in operation or the general heating system supplemented by other sources of heat may be employed to meet this requirement. [1910.94(c)(7)(iv)(b)]

(iii) No means of heating make-up air shall be located in a spray booth. [1910.94(c)(7)(iv)(c)]

(iv) Where make-up air is heated by coal or oil, the products of combustion shall not be allowed to mix with the make-up air, and the products of combustion shall be conducted outside the building through a flue terminating at a point remote from all points where make-up air enters the building. [1910.94(c)(7)(iv)(d)]

(v) Where make-up air is heated by gas, and the products of combustion are not mixed with the make-up air but are conducted through an independent flue to a point outside the building remote from all points where make-up air enters the building, it is not necessary to comply with (vi) of this paragraph (d). [1910.94(c)(7)(iv)(e)]

(vi) Where make-up air to any manually operated spray booth or room is heated by gas and the products of combustion are allowed to mix with the supply air, the following precautions must be taken: [1910.94(c)(7)(iv)(f)]

(A) The gas must have a distinctive and strong enough odor to warn workmen in a spray booth or room of its presence if in an unburned state in the make-up air. [1910.94(c)(7)(iv)(f)(1)]

(B) The maximum rate of gas supply to the make-up air heater burners must not exceed that which would yield in excess of 200 p.p.m. (parts per million) of carbon monoxide or 2,000 p.p.m. of total

combustible gases in the mixture if the unburned gas upon the occurrence of flame failure were mixed with all of the make-up air supplied. [1910.94(c)(7)(iv)(f)(2)]

(C) A fan must be provided to deliver the mixture of heated air and products of combustion from the plenum chamber housing the gas burners to the spray booth or room. [1910.94(c)(7)(iv)(f)(3)]